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244. Proposed by C. N. SCHMALL, New York City,

In a game of billiards a player observes two balls, A and B, at rest in a certain position and concludes that it would be to his advantage to project A against B in such a manner that, as a result of the impact, A might suffer the greatest possible deviation from its course. Taking the balls to be equal and smooth, each of diameter a and elasticity e, and the distance between their centers to be d, show that he can accomplish the desired motion by projecting A in a line making an angle equal to the

$$\sin^{-1}\frac{a}{d}\sqrt{\frac{1-e}{3-e}}$$

with the line joining the centers.

Solution by S. G. BARTON, Ph. D., Clarkson School of Technology.

Let α be the angle between the direction of the motion of the impinging ball and the line joining the centers at the time of impact, and x the required angle. We then have, from the law of sines,

$$\frac{\sin x}{\sin\alpha}=\frac{a}{d},\ \text{or}\ x=\sin^{-1}\left[\frac{a}{d}\sin\alpha\right].$$

When a moving smooth ball strikes another smooth ball of the same weight at rest, we have that the tangent of the angle between its original and new directions is (*c. f.* Bowser's *Analytic Mechanics*, problem 30, page 387),

$$\frac{1+e}{2}\cdot\frac{\sin 2\alpha}{1+\sin^2\alpha-e\cos^2\alpha}.$$

The deviation will be a maximum when its tangent is a maximum. Neglecting the constant, and differentiating for the maximum, we find the condition to be

$$\begin{aligned}&[1+\sin^2\alpha-e\cos^2\alpha]2\cos 2\alpha-\sin^2 2\alpha[1+e]=0,\\ \text{or, }&2[(1-e)+(1+e)\sin^2\alpha]\ [1-2\sin^2\alpha]-4\sin^2\alpha[1-\sin^2\alpha]\ [1+e]=0,\\ \text{or, }&2[1-e]-2[3-e]\sin^2\alpha=0;\end{aligned}$$

whence for the maximum deviation,

$$\sin\alpha=\sqrt{\frac{1-e}{3-e}},\ \text{and}\ x=\sin^{-1}\frac{a}{d}\sqrt{\frac{1-e}{3-e}}.$$

Also solved by G. B. M. Zerr.